

## XIX.—REPORT ON THE ARTIFICIAL PROPAGATION OF CODFISH AT WOOD'S HOLL, MASS., FOR THE SEASON OF 1886-'87.

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By CHARLES G. ATKINS

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The experiments in the hatching of codfish at the Wood's Holl Station for the season of 1886-'87 extended, in point of time, from the 16th of November to the 6th of April. The spawn was obtained, for the most part, from codfish brought in by the schooner *Grampus* from the Gulf of Maine, a single lot of 170 adults having been secured from local fishermen who had caught them at Nantucket Shoals and about 11,000,000 eggs having been taken by the *Grampus* from the fish on the fishing-grounds off Cape Ann. The hatching was all conducted in the hatching-room of the laboratory, and all, with the exception of a few experiments, in the Chester hatching-boxes. The total number of eggs handled was 43,575,000, of which 22,040,000, or a little more than 50 per cent., were hatched, and 19,495,000 were liberated alive in the waters of the adjacent coast.

The scale of operations, which under favorable circumstances might be greatly extended, was limited by the difficulties attending the collection of the parent fish. The first fish that came to hand were collected by the schooner *Grampus* to the eastward of Cape Cod and brought to the station on the 16th of November to the number of 195 codfish, together with a few pollock, haddock, hake, and cusk. Only the codfish yielded spawn. Another lot of adults, numbering 273 live codfish, were brought in by the *Grampus* from the same waters on the 9th of December; on the 11th of December 170 codfish were obtained from Nantucket Shoals; and, finally, on the 25th of January, 219 more were brought in from the Gulf of Maine by the *Grampus*. By the latter date the temperature of the sea along the coast, especially in the harbors, had fallen to so low a point that it seemed quite probable that an attempt to collect codfish and bring them to the station in the well of the *Grampus*, as had been done with the lots brought in by her so far, would fail by the death of the fish from the excessive cold to which they would be exposed should the vessel be compelled to seek a harbor during the trip.

The result of the observations heretofore made on this point is, in general, that codfish will live in water not colder than 30° Fahrenheit,

but that when it falls to 29° they all die, apparently through actual freezing. It has several times occurred at the Wood's Holl Station that all the adult fish on hand have died in this way in a single night. At the suggestion of Captain Collins, it was determined to attempt the collection of eggs directly from the fish on the fishing-grounds and transfer them to the Wood's Holl Station by rail. Mr. George H. Tolbert was sent from Washington charged with the manipulation of the eggs; and, with the assistance of the officers and crew of the *Grampus*, he collected and transferred all the eggs obtained after the 25th of January.

In an ordinary season the weather and other circumstances would be much more favorable to the capture of codfish than the winter of 1886-'87, and there would be no great risk attending their transfer from the Gulf of Maine to Wood's Holl up to the 1st of February. It might, therefore, be reasonably expected that a sufficient stock of breeding codfish could be gathered at Wood's Holl before the end of January to supply all the eggs that could be profitably incubated there.

The fish brought in by the *Grampus* were taken from her well in fairly good condition and placed in cars in one of the basins at the station. On the approach of dangerously cold weather in the winter an inclosure was made in the basement of the hatchery and the fish then on hand, and afterwards received, were placed therein. The experience of a single winter seems to warrant the belief that in such an inclosure fish will be safe from freezing in the severest weather.

The fish were overhauled from time to time, generally at intervals of two to four days, and the spawn and milt extruded into large pans containing a little sea-water, from which they were in a very short time washed off and placed carefully in the hatching-jars. The total number of gravid females found during the season was 108, and their average yield of eggs was about 300,000 each.

The first lot of eggs, taken on the 18th of November, began to hatch on the 26th, eight days from impregnation. The temperature of the water, which up to this time had been above 50°, fell steadily, until, on the 19th of January, it reached 32° Fahrenheit, the lowest reached in the hatchery during the season. The development of the spawn was, in consequence, so retarded that the lots taken in January and February were from twenty to twenty-five days in incubation. The best success attended the incubation of the eggs that were taken from the fish at the station in December and January. In several lots as high as 85 per cent. of the eggs put into the jars were successfully hatched, and in most cases all of the fry were liberated alive. Some of the lots of those months were, however, less satisfactory, the ratio of fry hatched being in some cases as low as 50 and 40 per cent., and the results obtained from those taken in November, and from those taken at sea and brought overland to the station in February and March, were even less satisfactory. From 11,150,000 transferred overland, but 722,500 were hatched.

It is a matter of common experience among fish-culturists that the

individuals that mature earliest in the season yield less healthy eggs than those spawning in the height of the season, and we may suppose that the eggs taken in November were from fish prematurely ripe. The unsatisfactory results from the eggs brought overland must, however, be attributed to the conditions under which they were taken and transferred. They were taken frequently under the great difficulties attendant on a boisterous sea and extremely cold weather, had generally to be kept over night, while awaiting shipment, in jars or other vessels, and their transfer by express involved their confinement for many hours, in a crowded condition, in small jars of water hermetically closed, with at best a scanty allowance of air. I do not think the ill success attending these transfers at all settles the question of the practicability of this method of collection under varied conditions. It might be possible to bring them through in perfect health by more careful attention to the necessity of a constant aeration of the water. This, however, is a matter for future experiment.

As a rule the fry were liberated as soon as practicable after they were hatched. If, as was commonly the case, the period of hatching out was protracted, those first breaking the shell were taken out of the jars and liberated, while the remainder of the lot were left in the jars to hatch. A single lot of the fry, numbering 2,050,000, was taken by the *Grampus*, on the 27th day of January, and liberated near Race Point in Cape Cod Bay. All the others were liberated in the immediate vicinity of Wood's Holl, sometimes on the flood tide, which would carry them into Vineyard Sound, and sometimes on the ebb, which would carry them into Buzzard's Bay.

The experiment was tried in several instances of keeping the fry in aquaria until they should attain some growth. The conditions of these experiments were greatly varied, but no satisfactory result was obtained in any case. Although appearing to be in good health when put into the aquaria, the fry invariably dwindled away until all or nearly all were gone. Egress was so guarded against that there seems little doubt that in most cases the disappearance was the result of death. It seemed impossible to so arrange the screens that the young cod would not be drawn against them and die. Whether the egress of the water was constant or intermittent (which latter condition we obtained by means of a tidal movement), in every case the result was practically the same.

A determination of the conditions under which cod fry can be reared, even to the age of a few weeks, presents to us, therefore, an unsolved problem. It will be necessary to inquire whether the difficulty does not arise, in part at least, from the crowded condition of the eggs in the hatching jars. These jars are of glass, 9 inches in diameter and 15 or 16 inches deep, and eggs enough are placed in one of them to form a layer at the surface a large fraction of an inch in thickness. When this apparatus is in operation the jar is covered closely with cheese-cloth and placed in the hatching-box in an inverted position, the water,

aerated by the artificial tidal motion, which is the most essential feature of this arrangement, rising and falling through the cheese-cloth and the complementary supply of air having ingress and egress through a hole bored in the upturned bottom of the jar. It is supposed that the ingress of water from the bottom disturbs the eggs enough to change their position and gives each egg its share of the water-supply; but it is questionable whether the arrangement secures sufficient change of water throughout the mass of eggs to maintain them in a condition of healthy and normal development. As yet there has been no opportunity of comparing the artificially hatched fry with those hatched in the natural way in the open sea.

A very important improvement has been effected in the water service during the past season. Two circular tanks with an aggregate net capacity of 17,000 gallons, have been erected alongside the coal-shed, and are served with a system of piping of which the mains are formed of log pipe wound with iron and covered with coal-tar, and the smaller pipes of hard rubber. We are consequently now entirely free from the difficulties that used to arise from the presence of iron rust in the pipes and hatching apparatus and which was, in fact, a very serious difficulty. The new system was put in operation on the 7th of December, and, with the exception of an occasional muddiness, resulting from heavy rainfall, the water has been admirably pure ever since.

The number of hatching boxes brought into operation during the winter was 24. They were arranged in series of three boxes each, and the amount of water fed to each series amounted to 150 gallons per hour, or a total of 1,200 gallons per hour. The total net capacity of the tanks is 17,000 gallons, so that in case of a suspension of pumping the hatchery can be made to run about fourteen hours without any curtailment of the quantity before the supply would be exhausted.

The Chester hatching boxes appear to be well adapted to the purpose of hatching buoyant eggs, yet, like most other new inventions, to be capable of simplification. A few boxes on essentially the same plan, but with simplified details, were constructed and found to work quite as well as those built on the original design. With the ordinary water-supply, which was about 150 gallons per minute, the period of each tidal pulsation was about ten minutes. The automatic action of the apparatus is well-nigh perfect, interference of the attendant being rarely necessary. It was, however, not considered prudent to leave the boxes without attention during the night, and the night watchman made regular examinations.

Observations on the temperature and density of the water in the hatchery were made daily through the months of December, January, February, and March. From these it appears that the density was very uniform, ranging from 1.0250 to 1.0260, and that the temperature of the water ranged from 49° to 32°, the mean for the months being 38.7°.

Subjoined will be found the report of Mr. James Carswell, who was in charge of the manipulation of the eggs and of the water observations.

#### REPORT OF MR. CARSWELL.

As desired, I submit the following report of cod-hatching for the winter of 1886-'87.

On my arrival at the station, on the 29th of November, I found in the hatchery a few cod eggs and fry. Some of the latter I put in an aquarium, but all got drawn upon the siphon bag and were lost. This I attributed to their sickly condition when put in.

On the 9th of December the *Grampus* arrived with 273 live codfish, and a smack, on the 11th of the same month, with 170, all of which were put into the live cars, and all proved to be good spawners. The first eggs taken were a small lot on the day of arrival, but these and the two following lots turned out badly, not hatching over 50 per cent. At the time they were taken I did not think they were likely to turn out well, because they scattered too much in the water when put in the hatching jars. Cod eggs when taken should at once rise to the surface of the water after being impregnated, and remain there until hatched; although in the case of very low temperature, when a long time is taken to hatch, the eggs will sometimes get coated with a very fine sediment and sink. Still, if they are far enough advanced for the young fish to be seen with the naked eye, they will hatch out, notwithstanding they have sunk to the bottom.

The codfish in live cars were examined every other day with varied success, the smallest number of eggs taken being 75,000, and the largest 3,200,000. All the eggs taken from the 13th to the 31st of December—about 18,000,000—turned out well, the average loss, as near as I could estimate, being about 20 per cent., but in several instances it did not exceed 5 per cent. I think the cod-hatching apparatus now in use at the Wood's Holl Station will compare favorably with any apparatus known to me and which is used for the hatching of other species of fish.

Experience has proved that it is not advantageous to have the temperature of the water above 40°. In warmer water the eggs hatch out too rapidly, the fry are weak and sickly, and a very large percentage of them die after hatching. I consider the best temperature to be from 34° to 38°, when the eggs will take from eighteen to twenty-five days in hatching; then the fry straighten out soon after hatching, look strong and vigorous, and invariably stay on the surface of the water. My experience is, the stronger the fry the nearer the surface they will remain.

From the 13th to the 31st of December I made several experiments in trying to keep the young fry alive in aquaria. First with the usual siphon-bag as in shad work; but in every case this resulted in drawing all the fry onto the cheese-cloth, where they would remain until they died. Next I fitted up three aquaria (see plans) and applied the tidal motion in three different ways, but this also resulted in the death of the fry after a time; not, however, on account of their sticking to the

cheese-cloth, as the draught was very slight and only lasted from five to fifteen minutes, when the return would come, releasing any that might have got onto the cloth, but from other causes which I am unable to account for. The best success obtained was in one of the smaller aquaria (No. 1), with a lot of very strong and healthy fry, which were put in on the 22d of January and did very well for some time, but all gradually died, and on the 14th of February all were gone. I also kept some of this lot in the hatching-jars, but they, too, died about the same time. I noticed that the sacs of most of them were gone before they died.

On the 25th of January the *Grampus* arrived with 162 live cod, which were put in the basement, and they lived equally as well there as in the cars. My experience in keeping large codfish alive is they will live anywhere, provided they have a plentiful supply of fresh salt-water and the temperature never goes below 30°; for at 29° all will die. Very few eggs were obtained from this lot of fish, as the majority were males and the females had mostly spent, and even those taken turned out badly on account of the poor condition of the fish when received.

I fitted up two tubs with the tidal motion and put in 1,000,000 eggs, which did very well for a few days, but owing to the high temperature of the hatchery and the large surface exposed to it, the temperature of the water in the tubs got too high and killed them all. I did not get another opportunity of trying the tubs, but from former experience I am satisfied good hatching can be done with them.

Several lots of eggs were received by express from Gloucester, and Mr. Tolbert brought three lots, in all about 11,000,000; and on each occasion from one-third to one-half died in transportation. On examining the apparently good ones with a microscope very many of them were found to be more or less defective, and, consequently, but few healthy fry were hatched out.

I submit the following suggestions for another season's work:

1. That there should be a supply of not less than 1,000 codfish at the station by the 1st of November, or as soon as they can be obtained from Nantucket Shoals.

2. That arrangements should be made for getting a monthly supply of at least 500 more. By this means the number would be kept up, and I think would furnish all the eggs the present force could handle.

3. That the basement be fitted up with a number of small pools, conveniently arranged, so the fish can be easily overhauled and get a plentiful supply of fresh water. This will obviate the chances of their getting killed by frost and afford an opportunity of examining them at any time.

Accompanying this you will find copies of the daily record kept during the season.

WOOD'S HOLL, MASS., March 25, 1887.

Record of cod-hatching at Wood's Holl, winter of 1886-'87.

(Prepared by James Carawell.)

[7]

PROPAGATION OF CODFISH.

789

Date of taking eggs.	From what fish taken.	No. fish yielding eggs.	Eggs obtained.	Date of hatching.		Fry hatched.	Planted.	Date of planting.	Remarks.
				Begin-ning.	Ending.				
1886.				1886.	1886.			1886.	
Nov. 18	Brought by Grampus.		150,000	Nov. 26		25,000			Nearly all lost by accidental cessation of water-supply.
	do		800,000		Dec. 6	400,000			
Dec. 9	Cars	2	75,000	Dec. 21	Dec. 24	37,500	37,500	Dec. 24	Eggs not very good when taken and temperature of water rather high.
10	do	7	900,000	Dec. 21	Dec. 24	450,000	450,000	Dec. 24	Do.
11	do	5	1,500,000	Dec. 23	Dec. 29	750,000	750,000	Dec. 29	Do.
13	do	8	1,800,000	Dec. 26	Jan. 3	1,500,000	1,500,000	Jan. 3	
14	do	1	600,000	Dec. 27	Jan. 5	900,000	900,000	Jan. 5	
15	do	6	2,500,000	Dec. 28	Jan. 9	1,125,000	1,125,000	Jan. 5, 10	Put 1,000,000 in hatching-tubs and lost them on account of high temperature.
18	do	9	3,000,000	Jan. 3	Jan. 14	2,550,000	2,550,000	Jan. 12, 14.	
20	do	8	2,500,000	Jan. 4	Jan. 17	2,000,000	2,000,000	Jan. 14, 17.	
22	do	8	3,200,000	Jan. 10	Jan. 22	2,700,000	2,000,000	Jan. 19, 25.	Lost 700,000 fry by keeping in aquaria.
24	do	7	1,400,000	Jan. 14	Jan. 21	980,000	980,000	Jan. 19, 21.	
27	do	10	2,500,000	Jan. 18	Jan. 27	2,000,000	1,000,000	Jan. 27	1,000,000 fry kept in hatching-jars and small aquaria.
31	do	6	1,400,000	Jan. 20	Jan. 27	1,050,000	1,050,000	Jan. 27	The fry put in aquaria all died by the 14th February; and those in jars by the 16th.
1887.									
Jan. 3	do	4	1,500,000	Jan. 25	Jan. 29	750,000	750,000	Jan. 29	
6	do	7	2,600,000	Jan. 28	Feb. 4	1,300,000	1,000,000	Feb. 5	300,000 kept in large aquaria; all died by the 17th February.
12	do	4	1,000,000	Feb. 3	Feb. 8	600,000	500,000	Feb. 11	100,000 kept in small aquaria; all died by the 16th February.
25	Basement	6	2,500,000	Feb. 12	Feb. 20	1,000,000	1,000,000	Feb. 19, 22.	
27	do	2	800,000	Feb. 17	Feb. 22	320,000	320,000	Feb. 25	
28	do	1	300,000	Feb. 18	Feb. 22	240,000	240,000	Feb. 25	
29	do	6	1,200,000	Feb. 18	Feb. 22	840,000	840,000	Feb. 25	
31	do	1	200,000	Feb. 20	Feb. 23	170,000	170,000	Feb. 25	
Feb. 7	Grampus		500,000	Mar. 1	Mar. 12	50,000	50,000	Mar. 13	Received from Gloucester by express at 6.50 p. m. February 8.
10	do		500,000			None			Received from Portsmouth by express; dead on arrival, 7 p. m. February 12.
13	do		150,000	Mar. 5	Mar. 15	22,500	22,500	Mar. 21	Tolbert brought from Gloucester 12 m. February 19.
17	do		1,250,000	Mar. 9	Mar. 18	250,000	250,000	Mar. 21	Do.
Mar. 2	do		2,500,000	Mar. 24		250,000	250,000	Apr. 4	Tolbert brought from Gloucester 12 m. March 4.
3	do		1,250,000	Mar. 29		150,000	150,000	Apr. 6	Received from Gloucester by express at 7 p. m. March 10.
14	do		5,000,000			None			Tolbert brought from Gloucester 7 p. m. March 15; all died by the 24th February.
	Total		43,575,000			22,040,000	19,495,000		

## Record of the planting of cod fry during the winter of 1886-'87.

[Prepared by James Carswell.]

Date.	Where planted.	By whom.	Number.	Species.
1886.				
Dec. 24	Wood's Holl Harbor	Olmston and Barry	487,500	Common cod.
29	do	do	750,000	Do.
1887.				
Jan. 3	do	do	1,530,000	Do.
5	do	do	880,000	Do.
10	do	do	725,000	Do.
12	Small Pool	Carswell	500,000	Do.
14	Wood's Holl Harbor	Olmston and Barry	2,050,000	Do.
17	do	do	2,000,000	Do.
19	do	do	2,500,000	Do.
21	do	do	480,000	Do.
27	Race Point, Cape Cod Bay	Captain Collins	*2,050,000	Do.
29	Wood's Holl Harbor	Olmston and Barry	750,000	Do.
Feb. 5	do	do	1,000,000	Do.
11	do	do	500,000	Do.
19	do	Olmston	750,000	Do.
22	do	do	250,000	Do.
25	do	do	1,570,000	Do.
Mar. 13	Small Pool	Barry	50,000	Do.
21	do	do	272,500	Do.
Apr. 4	Wood's Holl Harbor	Olmston	250,000	
6	do	do	150,000	
	Total		19,495,000	

\* Captain Collins reported the fry planted in splendid condition.

The fry put in harbor were sometimes put in on the flood tide, when they would be drawn into Vineyard Sound, and sometimes on the ebb, when they would be drawn into Buzzard's Bay.

## Record of temperature and density of water, winter of 1886-'87.

[Prepared by James Carswell.]

Date.	Temperature of water.			Density of water.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
1886.						
Dec. 1	49	49	40	1.0253	1.0253	1.0253
2	49	48	47	1.0253	1.0253	1.0253
3	43	43	43	1.0256	1.0256	1.0256
4	43	44	42	1.0256	1.0256	1.0256
5	43	43	39	1.0256	1.0250	1.0256
6	40	39	38	1.0258	1.0258	1.0258
7	39	38	38	1.0258	1.0258	1.0258
8	37	37	38	1.0258	1.0258	1.0258
9	38	38	38	1.0257	1.0257	1.0256
10	39	39	40	1.0256	1.0256	1.0256
11	40	40	40	1.0256	1.0256	1.0256
12	40	40	41	1.0256	1.0256	1.0256
13	41	41	42	1.0256	1.0256	1.0256
14	42	41	41	1.0256	1.0256	1.0256
15	41	42	42	1.0256	1.0256	1.0256
16	41	41	41	1.0253	1.0253	1.0253
17	41	38	41	1.0258	1.0258	1.0258
18	41	41	40	1.0258	1.0258	1.0256
19	40	40	40	1.0256	1.0256	1.0256
20	40	39	39	1.0256	1.0250	1.0256
21	40	39	39	1.0256	1.0256	1.0256
22	39	39	39	1.0256	1.0256	1.0256
23	39	39	39	1.0256	1.0256	1.0256
24	39	40	40	1.0256	1.0256	1.0256
25	41	41	40	1.0256	1.0256	1.0256
26	39	39	39	1.0256	1.0256	1.0256
27	39	39	39	1.0256	1.0256	1.0256
28	38	38	38	1.0256	1.0256	1.0256
29	37	38	37	1.0256	1.0256	1.0256
30	36	36	36	1.0254	1.0254	1.0254
31	36	36	36	1.0254	1.0254	1.0254
Mean		40			1.02559	



Record of temperature and density of water, winter of 1886-87—Continued.

Day of month.	January, 1887.		February, 1887.		March, 1887.	
	Temperature of water at 2 p. m.	Density of water at 2 p. m.	Temperature of water at 2 p. m.	Density of water at 2 p. m.	Temperature of water at 2 p. m.	Density of water at 2 p. m.
1.....	37	1.0255	37	1.0255	34	1.0258
2.....	37	1.0255	37	1.0255	35	1.0257
3.....	36	1.0255	37	1.0255	35	1.0257
4.....	36	1.0255	37	1.0255	35	1.0260
5.....	35	1.0255	35	1.0256	35	1.0260
6.....	35	1.0255	34	1.0255	34	1.0260
7.....	36	1.0254	34	1.0255	34	1.0259
8.....	35	1.0254	34	1.0255	35	1.0260
9.....	34	1.0254	35	1.0555	35	1.0260
10.....	34	1.0254	35	1.0255	35	1.0258
11.....	33	1.0256	36	1.0255	35	1.0260
12.....	33	1.0256	36	1.0254	35	1.0258
13.....	34	1.0256	35	1.0254	36	1.0257
14.....	35	1.0256	34	1.0255	35	1.0259
15.....	35	1.0256	34	1.0254	35	1.0252
16.....	34	1.0256	35	1.0255	36	1.0254
17.....	33	1.0256	35	1.0255	35	1.0252
18.....	34	1.0256	35	1.0255	36	1.0252
19.....	32	1.0256	36	1.0255	36	1.0252
20.....	33	1.0257	36	1.0255	37	1.0252
21.....	34	1.0256	36	1.0255	37	1.0252
22.....	34	1.0256	36	1.0255	37	1.0252
23.....	35	1.0256	36	1.0254	37	1.0252
24.....	36	1.0256	36	1.0255	37	1.0254
25.....	36	1.0256	37	1.0258	37	1.0254
26.....	37	1.0257	36	1.0258	37	1.0254
27.....	35	1.0255	36	1.0258	37	1.0252
28.....	36	1.0255	34	1.0258	38	1.0252
29.....	36	1.0255			38	1.0250
30.....	38	1.0255				
31.....	37	1.0255				
Mean.....	35	1.02554	35.4	1.02553	*35.8	*1.02552

\* 29 days.